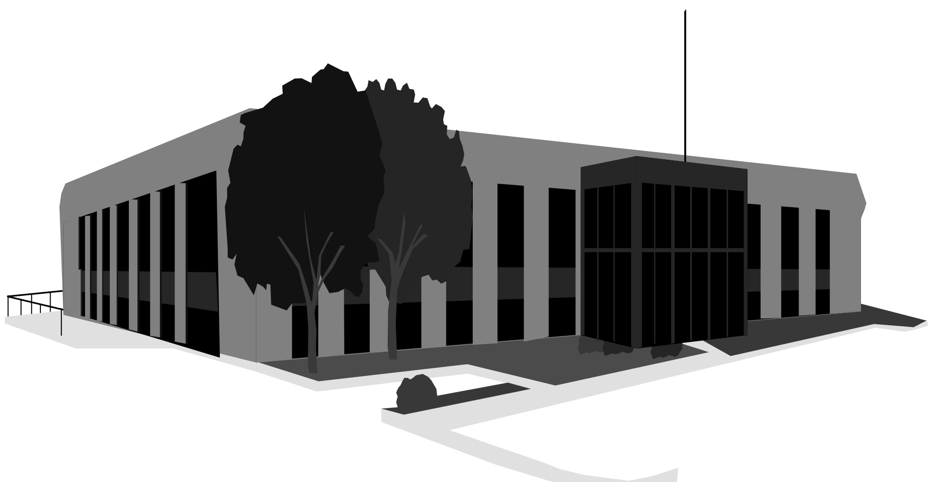
INDOOR AIR QUALITY REASSESSMENT

Massachusetts Department of Mental Health
Site Office Region II
40 Institute Road
Grafton, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
August, 2001

Background/Introduction

At the request of Bill Corliss, Massachusetts Department of Mental Health (MDMH), a reassessment of indoor air quality was done at the MDMH Site Office, Region II (the site office), 40 Institute Road, Grafton, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (DPH), Bureau of Environmental Health Assessment (BEHA). Employee concerns about poor indoor air quality and rodent infestation prompted the series of assessments of this building. On June 29, 2001, a visit was made to this building by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. BEHA staff conducted a previous assessment of this building and a report was issued (MDPH, 2000).

The site office is a two-story, wood frame building on the grounds of the former Grafton State Hospital. This building appears to have been originally built as patient housing. The date of construction is estimated to be 1930-40. After Grafton State Hospital was closed, this building was designated as excess state property and remained unoccupied for several years. The MDMH site office moved into the building in 1988. Reportedly, maintenance of the grounds is currently administered by the Department of Social Services.

The floor space was originally configured into four open wards with private patient rooms and nurse’s stations. Three of the four open wards are subdivided into work areas by five-foot high floor dividers. Each private patient room or nurse’s station was converted into a private office. The first floor north section was divided into a waiting room, conference room, kitchen and shared office space. Windows are openable in some areas of the building. Prior to occupancy by the MDMH site office, the interior of the building was renovated. Two air handling units (AHUs) were installed at ground level at the front of the building (see Pictures 1 and 2). Suspended ceilings were installed on both floors. The existence of a thick layer of fiberglass insulation on top of the suspended ceiling on the second floor indicates that the renovations were an energy conservation measure.

Actions Taken on Recommendations

BEHA staff made 10 short term and 5 long-term recommendations to improve indoor air quality in this building (MDPH, 2001a). BEHA staff confirmed in February 2001 that the following actions were taken: the heating system of the building was disconnected from the campus steam plant, a furnace was installed and carpeting was removed on the first floor. The following is an update on all actions taken in response to BEHA recommendations, based on reports from MDMH personnel and/or direct observation by BEHA personnel during this re-evaluation.

Short Term Recommendations

1. **Consider consulting a disaster remediation consultant concerning rodent carcass odor remediation.**

   Action Taken: The building was free of rodent carcass odor, however MDMH staff report ongoing mouse infestation problem.

2. **It is highly recommended that the principles of integrated pest management (IPM) be used to rid this building of pests. Holes as small as ¼" provide enough space for rodents to enter an area. Examine each room and the exterior walls of the building for means of rodent egress and seal. If doors do not seal at the bottom, install a weather strip as a barrier to rodents.**

   Action Taken: Exterior doors continue to have spaces wide enough to serve as rodent entryways (see Picture 3). Holes in the rear foundation wall are also wide enough to admit rodents (see Picture 4). A pipe downhill from the building that protrudes from the hill may also serve as a rodent entryway (see Picture 5).

3. **Operate HVAC systems during periods of occupancy. Consider having the mechanical fresh air supply and exhaust balanced by an HVAC engineer. Increase the percentage of fresh air if necessary.**

   Action Taken: The ventilation system was not operating during this visit. Both air handling units (AHUs) were idle and no airflow was detected from fresh air diffusers.

4. **Once operating, have the ventilation system balanced.**

   Action Taken: No information concerning balancing of the ventilation system was not available during this reassessment.

5. **Repair leaks from the heating system that is moistening carpeting.**

   Action Taken: The heating system leak was repaired and carpeting was removed from the conference room.

6. **Remove water damaged carpeting along walls on the first floor. Remove carpeting along the base of the floor to ceiling ducts in the second floor.**

   Action Taken: Carpet was removed from the first floor and replaced with tile.

7. **Replace missing ceiling tiles.**

   Action Taken: Missing ceiling tiles were replaced. Some ajar ceiling tiles remain in the building.

8. **Consider obtaining a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to trap respirable dusts.**

   Action Taken: A HEPA filter equipped vacuum cleaner was obtained.

9. **Replace plastic hose for condensation drains.**

   Actions Taken: The units connected to ducts were humidification units, not condensation drains. The equipment to replace these units was obtained, but not fully installed (see Picture 6). Plastic hoses were not replaced.

10. **Remove filters from the interior of AHUs. Install filters in AHUs filter racks. If no racks exist in the AHUs, examine the feasibility of installing filter racks that allow for proper filtration of air and ease of filter replacement.**

    Action Taken: Filters were removed, however no filter racks were installed. Therefore, unfiltered outdoor air is introduced into the building when AHUs are operated.

Long-term Measures

1. **Continue with plans to renovate the heating system.**

   Action Taken: Heating system was replaced (MDPH, 2000). Building occupants reported that furnace exhaust was detected inside of the building because of the furnace exhaust vent's configuration. The terminus of the furnace exhaust vent is now above the peak of the roof, which has reportedly eliminated reports of furnace odors inside the building.

2. **As part of the renovation, ensure that the heating elements in the air mixing room are deactivated for better temperature control.**

   Action Taken: These heating elements were reportedly disconnected and vents leading to this room were sealed (see Picture 7).

3. **Examine the feasibility of installing general mechanical exhaust ventilation.**

   Action Taken: No general exhaust ventilation system had been installed at the time of this reassessment.

4. **Consideration should be given to reconfiguring the ventilation system ductwork so that each AHU services one horizontal floor in order to better control heating.**

   Action Taken: No information concerning whether this recommendation was provided.

5. **To decrease condensation in ductwork during summer months, consider insulating the exterior of ducts.**

   Action Taken: Exterior of exposed ductwork in office space was not insulated at the time of this assessment.

6. **Examine the feasibility of extending restroom exhaust vent out the wall of the building.**

   Action Taken: No extension of restroom exhaust vents was noted.

BEHA staff also made a number of recommendations concerning actions to be taken to prevent renovation-generated pollutants from impacting occupied areas of the building (MDPH, 2000).

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

These offices have an employee population of 28 with approximately one to two members of the general public visiting the space daily. The tests were taken under normal operating conditions. Test results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that the carbon dioxide levels were above 800 parts per million of air (ppm) in fourteen of fifteen areas sampled, which normally indicates inadequate ventilation. However, neither AHU was operating at the time of the assessment. The fresh air intake louvers were also found closed, which limits the amount of fresh air drawn into each AHU when they are operating. The sole source of fresh air in the building during the current assessment was air penetrating through cracks and seams in window frames and the periodic opening of exterior doors.

The heating, ventilating and air-conditioning (HVAC) system consists of several independently operating components: a retrofitted mechanical ventilation system and baseboard heating units located in first floor offices. The two AHUs located at ground level in the front of the building provide mechanical ventilation. Each AHU is connected to ductwork above the ceiling that distributes air to ceiling mounted air diffusers. Air diffusers are designed to create airflow by directing air to move along the ceiling and walls. This allows air to mix, creating circulation. The AHUs do not provide exhaust ventilation. Return air is drawn to each AHU by ceiling mounted exhaust vents through ductwork. Without an operating ventilation system, no fresh air can be delivered mechanically into the building.

The private offices do not have air diffusers. Occupants of private offices reported experiencing cold temperatures. In order to improve temperature control, a heating system was installed in these rooms. The only source for fresh air in these offices appears to be openable windows or air infiltration through the front door of the building.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings at the site office were within the BEHA recommended comfort range (ranging from 71^{o} F to 75^{o} F). The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Whether the installation of the furnace provides better temperature control for the building could not be determined outside of the heating season.

Relative humidity measurements ranged from 42 to 50 percent throughout the building, which were also within the BEHA comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity measurements would be expected to be near or below the relative humidity outdoors. Of note, however, were several areas that had relative humidity measurements 1 to 6 percent higher than the relative humidity measured outdoors (44 %) on the day of the assessment. This increase of relative humidity can be attributed to a lack of airflow. Without airflow created by the mechanical ventilation system, water vapor from occupants can build up, as demonstrated by these relative humidity measurements. Relative humidity levels would be expected to drop during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The conditions concerning ductwork-supplying air to the second floor remain. Each former open ward has floor-to-ceiling ductwork that delivers air to ceiling mounted fresh air diffusers in the suspended ceiling. AHUs also have the capacity to provide air-conditioning during summer months. The ductwork on the second floor is not insulated, which can result in the generation of condensation on its chilled metallic surface. When warm, moist air passes over a surface that is colder than the air, water condensation can collect on the cold surface. Over time, water droplets can form and then drip from a suspended surface. At the base of each duct is wall-to-wall carpeting that may have become chronically moistened by condensation during summer months.

Carpeting can be susceptible to mold growth if allowed to remain moist. If mold has colonized carpeting, the addition of moisture can result in increased mold growth. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

The equipment initially identified as condensation pumps are actually a humidification system. Humidification equipment, if not maintained, can be a source of moisture in an HVAC system and a source of microbial growth. According to building staff, the humidification system has not functioned for some time. The interior of the ductwork connected to the humidification system could not be examined during the assessment. If repairs are not made to the humidification system to restore its function, it is advised to remove the system from the ventilation ductwork. The humidification systems are connected to the drainage system by clear plastic flexible hoses. The interior of these flexible hoses are coated with microbial growth. As the ventilation system operates, negative pressure is created that can draw air from the drain system through these hoses and into the unit. This can be a means for microbial growth and associated odors to be drawn into each unit and distributed by the HVAC system.

Other Concerns

Former exhaust ventilation shafts exist on the roof (see Picture 8). The louvers do not appear to have screens to prevent rodents (chipmunks and squirrels) from entering the building. These holes should be equipped with screens to keep rodents from the interior of the building.

AHUs are no longer equipped with filters. AHUs are normally equipped with filters that strain particulates from airflow. The filters provide filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can reduce the efficiency of the AHUs due to increased resistance. Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

While several steps have been taken to improve indoor air quality in this building, a number of recommended steps with regard to the AHUs have not been implemented. Based on these observations, the following recommendations are made:

1. Fully implement recommendations made in previous reports (MDPH, 2000, MDPH, 2001a and MDPH 2001b), with an emphasis on operating the AHUs with proper filtration. If this cannot be achieved with existing equipment, consider replacing the AHUs with models that can both provide fresh air and exhaust ventilation.
2. Examine the drainpipe shown in Picture 5 and install a screen to prevent rodent ingress. Ensure that maintenance staff checks the screen for clogging weekly or after heavy precipitation to prevent backups.
3. Install screens on rooftop vents to prevent rodent ingress.
4. Consider removing humidification system from ducts. Seal ducts once humidification system is removed.

References

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Picture 1

AHU Servicing North Zone of Building

Picture 2

AHU Servicing South Zone Of Building

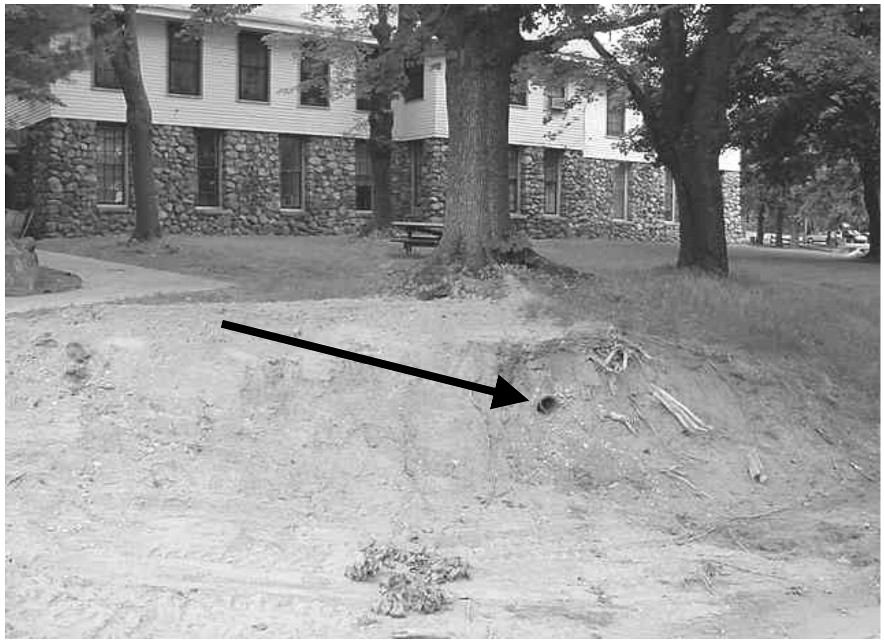
Picture 3

Space Between Exterior Door and Its Doorframe

Picture 4

Holes In Foundation

Picture 5

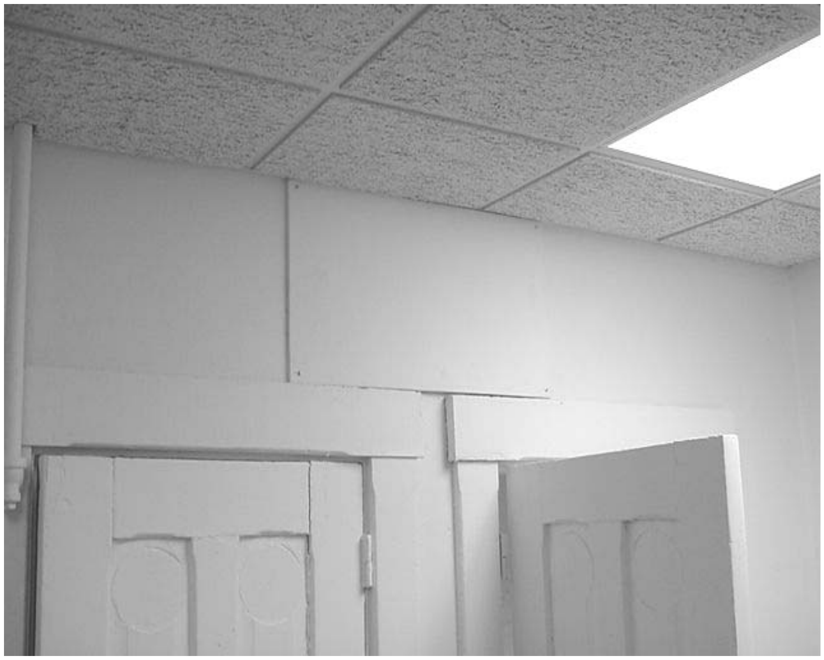


Drain Pipe below MDMH Building

Picture 6

Parts of Humidification System to Be Installed

Picture 7



Sealed Vent outside Mainframe Room

Picture 8

Open Louvers of Rooftop Exhaust Vent

TABLE 1

Indoor Air Test Results – Massachusetts Department of Mental Health, Site Office Region II, 40 Institute Road, Grafton, MA June 29, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	486	75	44					
NE Office Pietrzuk	791	72	44	0	Yes	No	No	Water damaged carpet, door open
North Stairwell	908	72	44	1	Yes	Yes	Yes	Supply and exhaust off
Walter's office	878	72	44	1	Yes	No	No	Door open
Sullivan Office	956	73	43	1	Yes	No	No	Plants, door open
Parmenter Office	911	73	43	0	Yes	No	No	Door open
South Stairwell	830	74	42	1	Yes	Yes	No	
Director's Office	879	75	44	0	Yes	No	No	Window-mounted A/C
South Outer Cubicles	905	73	43	2	Yes	Yes		
South Inner Cubicles	886	73	44	1	Yes	Yes		missing CT

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Massachusetts Department of Mental Health, Site Office Region II, 40 Institute Road, Grafton, MA June 29, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Main Frame Room	1004	72	45	0	Yes	No	No	2 missing CT, 2 water damaged CT
Inner Office	974	71	45	1	No	Yes	No	Supply off
Meeting Room	829	70	47	0	Yes	Yes	Yes	Missing CT, supply and exhaust off
Front Desk	930	70	49	2	Yes	Yes	Yes	4 ajar CT, supply and exhaust off
Kitchen	931	70	50	0	Yes	Yes	Yes	2 missing CT, water damaged CT
McNamara Office	867	71	50	0	Yes	No	No	Missing CT, water damaged CT

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CT = ceiling tiles

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